SERIAL NUMBER : 09/806704

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FORM PTO-1390 (Modified) (REV 11-98) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE		ATTORNEY'S DOCKET NUMBER 3821.02`
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR 09/806704
INTERNATIONAL APPLICATION NO. **PCT/EP 99/07340**	INTERNATIONAL FILING DATE **04 OCT 1999 (04.10.1999)**	PRIORITY DATE CLAIMED **05 OCT 1998 (05.10.1998)**

TITLE OF INVENTION
System and Method for Monitoring the Performance of Dense Wavelength Division Multiplexing Optical Communications Systems

APPLICANT(S) FOR DO/EO/US
Adalbert BANDEMER
Dieter PALME

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
   - a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau).
   - b. ☐ has been transmitted by the International Bureau.
   - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☐ A copy of the International Search Report (PCT/ISA/210).
8. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
   - a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   - b. ☐ have been transmitted by the International Bureau.
   - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   - d. ☐ have not been made and will not be made.
9. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
10. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
11. ☐ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).

Items 13 to 20 below concern document(s) or information included:

13. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☐ A **FIRST** preliminary amendment.
16. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
17. ☐ A substitute specification.
18. ☐ A change of power of attorney and/or address letter.
19. ☐ Certificate of Mailing by Express Mail
20. ☒ Other items or information:

Small Entity Assertion
Express Mail Label: EL354325184US

JC02 Rec'd PCT/PTO 0 4 APR 2001

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR 09/806704	INTERNATIONAL APPLICATION NO. PCT/EP 99/07340	ATTORNEY'S DOCKET NUMBER 3821.02`

21. The following fees are submitted:.

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :

		CALCULATIONS	PTO USE ONLY
☐ Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2) paid to USPTO and International Search Report not prepared by the EPO or JPO	**$970.00**		
☒ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but Internation Search Report prepared by the EPO or JPO	**$840.00**		
☐ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO	**$690.00**		
☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4)	**$670.00**		
☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4)	**$96.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =		**$840.00**	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).		**$0.00**	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	- 20 =	0	x $18.00	**$0.00**	
Independent claims	- 3 =	0	x $80.00	**$0.00**	
Multiple Dependent Claims **(check if applicable)**.			☐	**$0.00**	
	TOTAL OF ABOVE CALCULATIONS		=	**$840.00**	
Reduction of 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28) **(check if applicable).**			☒	**$420.00**	
	SUBTOTAL		=	**$420.00**	
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (f)).			+	**$0.00**	
	TOTAL NATIONAL FEE		=	**$420.00**	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) **(check if applicable).**			☐	**$0.00**	
	TOTAL FEES ENCLOSED		=	**$420.00**	
				Amount to be: refunded	$
				charged	$

☒ A check in the amount of **$420.00** to cover the above fees is enclosed.

☐ Please charge my Deposit Account No. **50-0636** in the amount of to cover the above fees. A duplicate copy of this sheet is enclosed.

☒ The Commissioner is hereby authorized to charge any fees which may be required, or credit any overpayment to Deposit Account No. **50-0636** A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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22337
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SIGNATURE

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NAME

30,640
REGISTRATION NUMBER

04 APR 2001
DATE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Adalbert BANDEMER et al. **Attorneys Docket:** 3821.02

PCT Application: PCT/EP 99/07340

US Serial No.: unknown **Art Unit No.:** unknown

Filed: herewith **Examiner:** unknown

For: "SYSTEM AND METHOD FOR MONITORING THE PERFORMANCE OF DENSE WAVELENGTH DIVISION MULTIPLEXING OPTICAL COMMUNICATIONS SYSTEMS"

Commissioner of Patents and Trademarks
Washington, DC 20231

ASSERTION OF SMALL ENTITY STATUS UNDER 37 CFR §1.27(c)(1)

Sir:

The undersigned attorney asserts under 37 CFR §1.27(c)(1) that Applicants are entitled to small entity status.

Respectfully submitted,

Charles S Guenzer

Charles S. Guenzer
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Date: 4 April 2001

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09/806784
Rec'd PCT/PTO 27 JUN 2001
PCT/EP99/07340

System and Method for Monitoring the Performance of Dense Wavelength Division Multiplexing Optical Communication Services

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In densely packed WDM systems (dense WDM, DWDM) messages are communicated by light signals at different wave lengths via a single fiber only. Each wave length is the carrier of an information signal. All channels are within the wave length range from presently roughly 1,520 nm to 1,565 nm. The inter-channel separation amounts to a few nanometers or some hundreds of picometers, respectively. For standardization of these telecommunication systems, the international ITU-T Working Group has recommended the wave lengths (corresponding to the channels) to be used with an inter-channel separation of 100 GHz (□ 0.8 nm) as standard. The ongoing development of these DWDM systems aims at the extension of the utilizable wave length range up to 1,610 nm for example.

Systems for the continuous monitoring of all characteristic parameters with the possibility of signal regeneration or improvement are required at many sites of this communication system. The most important parameters include the wave length and the capacity of all channels, the monitoring of the line width and the wave length drift of the lasers as well as the signal-to-noise ratio in each communication channel. Typical specification requirements for monitoring are:

- wave length measurement per channel with an absolute precision of 0.08 nm and a resolution of 0.01 nm,
- power metering per channel with an absolute precision of 0.4 dB and a resolution of 0.1 dB,
- S/N measurement between the channels with an absolute precision of 0.4 dB at 0.1 dB,
- reproducibility and a dynamic ratio of 33 dB at minimum,
- reliability over 10^{10} measuring cycles (20 years approximately),
- low PDL (0.1 dB max.),
- small physical size.

Fundamentally different methods are suitable for monitoring purposes, which are employed in conventional optical spectrum analyzers.

Tunable narrow-band filters are used for wave length selection in the filtering technique. Acousto-optical filters (e.g. those produced by Wandel & Goltermann) or piezo-electrically controlled micro filters (e.g. those from the Queensgate company) or tunable fiber Bragg gratings (e.g. those from ElectroPhotonics Corp.) are applied, which can be tuned directly via an electrical parameter.

The filtering technique is not only restricted to the optical filtering operation but it may also be performed at the electrical signal level after a preceding conversion into electronic signals. With electronic filtering, the optical signal is mixed with an optical reference signal in a non-linear optical component while the differential frequencies are analyzed on an electronic spectral analyzer (Hewlett Packard Co.).

Another variant is the grating monochromator technique wherein either the grating is rotated or the spatially resolved signal spectrum is sensed by means of a single photodiode, or the grating is stationary and a scanning deflection mirror is provided in front of the exit slit of the monochromator, or a mobile reflecting element varies the angle of incidence of the radiation on the grating (e.g. Photonetics company), or a stationary grating is used in combination with a line of photodiodes as detector unit (e.g. Yokogawa company).

In the interferometric technique, the spectrum is obtained from the detector signal of a Michelson interferometer with variable optical paths, with application of the Fourier transform (e.g. Hewlett Packard company).

None of the aforementioned conventional systems is suitable to satisfy the high demands made on a monitoring module for a DWDM system in terms of resolution, measuring accuracy, ASE measurement and dynamic ratio, at the same time and in a suitable manner and to satisfy moreover the demands in terms of short measuring intervals, longevity and low space requirements as well as low-cost realization.

The present invention is now based on the problem of implementing a suitable measuring system that satisfies the demands on a DWDM monitoring system in terms of resolution, measuring accuracy, ASE measurement and dynamic ratio, short measuring intervals, longevity and low space requirements as well as a low-cost production.

In accordance with the present invention this object is achieved with a system permitting two variants. This aim is firstly reached in accordance with the invention with a narrow-band tunable band-pass filter in the form of a specific grating spectrometer permitting a high resolution and a high-speed sampling of the measured values according to Variant 1 as illustrated in Fig. 1, and secondly the solution according to the present invention is presented in a Variant according to Fig. 2 as a purely electronic solution using an opto-electronic cross correlator.

Variant 1:

Fig. 1 illustrates the fundamental structure of the embodiment including a fiber input 5, a narrow-band tunable band-pass filter 1 and an analyzer 3.

High-resolution spectrometers generally require several dispersive and imaging elements and are adjusted to the wave length to be detected in a complex manner.

An example of a system based on a multiple spectrograph is illustrated in Fig. 3. The measuring light arrives through a fiber optical waveguide 5 into the optical unit 13 including the spectrometer. The light selected by a particular wave length arrives from the optical unit 13 on the photo detector 11. The electrical signal obtained from the measuring light in the photo detector is passed via a low-pass filter 6 to the signal processor 7. There the wave length is assigned which the reference unit 9 has determined from the position signal 8 of the position sensor 28 and which arrives at the signal processor 7, too. That processor generates also the necessary control signals for the driving unit 10 and the grating drive 12 that adjusts the wavelength-determining element in the optical unit 13. The characteristic values of the instantaneously set wave length, which are calculated in the signal processor, are displayed to the user in the display unit 14 and made available for being passed on.

The problem to achieve a high resolution is solved, in accordance with Fig. 4, by the structure of a specific grating spectrometer 1 wherein an echelle or ruled grating or a blazed grating for the wave length range to be monitored is mounted in a combined array according to Ebert and Fastie and by approximation in a Littrow array. The optical paths for the incident and exiting light are almost symmetrical there. Due to the multiple use of the grating and the single imaging element, that is equally provided for multiple use, in combination with several beam deflection systems composed of flat mirrors or prisms, a compact, stable, highly dispersive and low-cost structure is achieved. A predominantly symmetrical optical path in the optical unit reduces imaging errors resulting a dramatic impairment of the resolution. The movement of the grating for wave length selection can take place at a high speed because only a single element is moved. The application of a single detector element only prevents site-dependent or element-dependent variations in the responsiveness. Moreover, a further-going independence from polarization effects such as PDL (polarization-dependent losses) is achieved because with the blazed grating or the ruled grating, respectively, the beams are incident on the diffracting grating surfaces almost orthogonally and cover a wide grating length at a high angle of incidence with a small beam diameter.

The angular position of the dispersing grating, that is decisive for assigning the measuring wave length, is determined by means of an auxiliary means, the position sensor, according to Fig. 5.

For a general grating the fundamental equation

$$m\lambda = d(\sin\alpha + \sin\beta) \qquad \text{(I)}$$

wherein m denotes the order, d represents the inter-line spacing and α, β indicate the angles of incidence or exit, respectively. As in a Littrow array grating the angles of incidence and exit are almost identical, the definition according to Fastie furnishes the following simplified equation:

$$m\lambda = 2\,d\sin\alpha \qquad \text{(II)}$$

In the definition according to Ebert the basic equation (I) applies. The optical path of the beams is so designed that the most symmetrical optical path possible will be available with respect to the concave mirror. As in this case, too, the angles of incidence or exit are almost equal the angular dispersion comes also under a similar magnitude order as in the definition according to Fastie. Due to the multiple passages - here quadruplicate, for instance - of the radiation through the dispersive element the overall dispersion and hence the resolution of the device is quadruplicated, too. On account of the utilization of mirror areas n symmetrical positions, the symmetrical optical path relative to the imaging concave mirror results in an extensive compensation of the imaging errors, particularly of astigmatism that leads to a substantial deterioration of resolution.

With a dielectric optical preliminary filter as band-pass element in the multiple optical paths any light of wavelengths beyond the DWDM range is suppressed. In such a case the filter is then passed only by the DWDM range, for instance, with a width of roughly 100 nm.

The detection of the entire spectrum is performed by a single radiation detector while the adjustment of the wave length to be detected is realized by rotating the grating about its vertical axis, which is performed both by motor drive means and by the configuration as spring-mass array with torsion bars, capable of oscillating.

Furthermore, the position of the grating is detected by a secondary laser with a very high precision. The focused beam of the secondary laser is directed onto a reflecting surface rigidly connected to the grating while the reflected beam is supplied to a position sensor including an incremental scale.

Fig. 4 illustrates an example of an appropriate embodiment. The light to be examined arrives through the entrance opening, that is configured as fiber input 25, into the optical system. The diverging optical path is shaped by the collimator and camera mirror 27 to achieve a parallel pencil that is passed on by approximation onto the grating 24 at the blaze angle. The diffracted pencil then arrives again at the collimator and camera mirror 27, is focused by the latter and arrives on the mirrors 21 and 22 where it is deflected in a way that now the pencil, which is divergent again, is passed along an axis parallel with the axis of the collimator and

the camera mirror 27. The parallel pencil then arrives at the grating 24 again, is diffracted there again and is incident on the collimator and camera mirror 27. From there, the beam is now directed to the mirror 15 and via the mirrors 16, 17 and 18. The beam has now reached a position above the optical axis and is incident again on the collimator and camera mirror 27, arrives from there again at the grating 24 and arrives via the collimator and camera mirror 27 on the grating 24 a second time. From there, the beam, that is now dispersed even more strongly, arrives again at the collimator and camera mirror 27 and is passed from there to the mirrors 19 and 20, is incident on the collimator and camera mirror 27 again, then on the grating 24, and then on the collimator and camera mirror 27 for the last time. The focused and four times dispersed beam then arrives at the signal output 26. All beams arriving on the grating 24 several times and returned from there back to the collimator and camera mirror 27 again must pass through the dielectric band-pass filter 23 and are cut there to the useful frequency band.

Fig. 5 illustrates an example of a structure for detecting a position. The light of a secondary laser 41 is focused through the optical system 42 on the incremental scale 45. The rotation of the grating 43 and the involved rotation of the mirror 44 rigidly connected to the grating results in a deflection of the laser beam over the incremental scale 45.

The influence which the incremental scale takes on the laser intensity is detected by the joining detector 46 and made accessible for analysis.

Variant 2:

The Variant 2 according to Fig. 2 - an entirely electronic solution in the form of an opto-electronic cross correlator 2 - applies to methods known per se from high-frequency technology. In this case, however, two optical signals are mixed with each other without a previous conversion into electrical signals. These two signals are firstly the working light 5 to be examined and secondly the reference light originating from a tunable laser 4. When the reference oscillator (laser) is tuned a beat frequency is created whose frequency decreases as it approaches the frequency of the working light; when the frequencies are equal it approaches

zero. This permits the use of components envisaged for application in the low-frequency range and hence also for the mixer output of a high-impedance load resistor. This results in a substantial improvement of the responsiveness in detection. While the solutions known from the technique of optical superposition or interference operate usually on a load resistance of 50 Ohm, this array allows for the application of resistors of some kilo Ohm. The frequency range to be processed extends from a freely selectable lower frequency limit , that is expediently higher than interfering mains frequency and base band components caused by the modulation of intensity of the optical carriers, up to an upper frequency limit which determines the bandwidth of integration. This frequency is expediently not substantially lower than the spectral width of the tunable laser acting as local oscillator. The advantage of such a system resides in the compact design, in the omission of mobile parts, in a purely electronic solution using components appropriate for application in the low-frequency range, in the measuring rate restricted only by the tuning speed of the reference oscillator, and in a high responsiveness at an almost optionally small bandwidth of analysis.

The two light signals are defined by the following two relationships:

$$\mathbf{E}_M = E_M \left[i \int_0^t \omega\, t\, dt \right] e_M$$

$$\mathbf{E}_R = E_R \left[i \int_0^t \Omega\, t\, dt \right] e_R$$

This results in the following photo-electric current:

$$\mathrm{I} = \left| \mathbf{E}_M + \mathbf{E}_R \right|^2$$

$$= \mathbf{E}_M * \mathbf{E}_R + \mathbf{E}_R * \mathbf{E}_R + 2\,\mathrm{Re}\,\{ \mathbf{E}_M * \mathbf{E}_R \}$$

$$= E_M^2 + E_R^2 + 2\, E_M E_R \cos \left[\int_0^t (\omega - \Omega)\, t\, dt \right]$$

It is apparent that the last term defines a current variable in time, that is dependent on the amplitudes of both radiations and on the difference of the light frequencies. When both frequencies are approaching each other a low-frequency signal is created with the maximum amplitude $I_{max} = 2\, E_M E_R$. Moreover, the direction of polarization of both light sources is equally considered. In order to eliminate this dependence, it is possible, on the one hand, to render the reference light laser or the source of working light statistically variable in terms of its direction of polarization, or, on the other hand, to make two orthogonally polarized beams available, for instance, as reference light sources while the optical mixture is performed in two separate detectors with a subsequent logic operation in the signal processor. For another solution, for example, it is possible to switch the reference laser over in a time-sequential manner in the polarization plane while the subsequent measurements in succession are subjected to a logic operation in the signal processor.

Fig. 6 shows an example of Variant 2. The radiation to be measured arrives as working beam via the fiber input 5 on a non-linear optical component, the detector 32. At the same time, the reference beam 40 is passed via the polarizer 47 to the detector 32. The electrical mixed products generated from the optical signals arrive via the low-pass filter 33 to the rectifier 34 and from there at the digital signal processor 35 which realizes the evaluation of the signals, controls the display unit 36 and supplies the reference laser controller 37 by means of the tunable 38.

By employment of the wave length calibrator 29 for wave length assignment the provision of wave length references is made possible in both variants. To this end known arrays such as absorption cells are suitable for this purpose, which contain gases displaying characteristic lines of absorption in the required wave length range. When such a cell is inserted into the optical path, for instance in the spectrometer, and when the system is exposed to wide-band illumination characteristic signal developments are created which permit a precise assignment of the wave lengths. Another possibility is the measurement o the reference laser wave length by means of an additional interferometer array. In such a system, one part of the light from the tunable reference light laser is passed on to an interferometer that is provided

with a supplementary highly precise light source and in which the interference signals variable in time, which are generated when the reference light laser is tuned, serve to assign the wave length present in that moment.

The combination of the working light and the reference light can be realized in different manners. Fig. 6 illustrates the free irradiation with the measuring light, the reference light and possibly the calibration light, which are incident on the non-linear detector component 32.

Fig. 7 shows that the various beams are combined by means of a fiber optical component that is implemented in the form of a bulk or Y-type fiber coupler 48. The working signal at the fiber input 31 arrives via the coupler 48 at the detector 32. The light of the reference laser 38 is combined with the light of the wave length calibrator 29 via the polarizer 47 in another coupler 48 and added to the working light in a first coupler 48.

Fig. 8 illustrates an example of a dual-channel design permitting the consideration of the aforementioned dependence on polarization. The working light is subdivided into two channels of orthogonal polarization by means of a polarizing beam splitter 49. The reference laser 38 is equally split into two beams of orthogonal polarization and passed, together with the associated working beams, to two separate detectors 46. The output signals of both detectors then arrive at the signal processor 35 where they are processed.

PATENT CLAIMS

1. System for monitoring the performance of DWDM multi-wavelength systems, characterized in that a narrow-band and tunable low-pass filter (1) for the DWDM range is provided in a purely electronic form based on the principle of opto-electronic mixing in the form of a cross correlator (2).

2. System according to Claim 1, characterized in that the grating (24) in the form of a Littrow system both in the form of Ebert's array and in the form of an array according to Fastie is disposed for the multiple passage.

3. System according to Claim 1 or 2, characterized in that a grating is provided which is a ruled grating for avoiding polarization-dependent reflections, and which ensures an almost orthogonal incidence on said grating (24).

4. System according to the Claims 1 to 3, characterized in that a dielectric preliminary filter (22) is provided for suppressing wave lengths beyond the working range, which, due to the multiple passage, multiplies its efficient quality.

5. System according to Claim 4, characterized in that said grating (24) is provided for both a rotational movement and a periodically oscillating movement for wave length adjustment.

6. System according to Claim 5, characterized in that the combination of a moved grating (24) with an optical position sensor (28) is provided.

7. System according to the Claims 1 to 6,
characterized by a secondary laser (41) for scanning the moving object in order to derive a synchronizing signal for wave length assignment of the output signal of the system.

8. System according to the Claims 1 to 8,
characterized by a position sensor (28) for deriving a position signal (8) of the moving object.

9. System according to the Claims 1 to 8,
characterized in that said position sensor (28) consists of a line-shaped photodiode (46) with an incremental scale (45) disposed in front of it.

10. System according to Claim 1,
characterized in that for optically mixing two optical signals for the generation of a working signal, a non-linear opto-electronic component (30) is provided.

11. System according to Claim 1 or 10,
characterized in that said non-linear opto-electronic component (30) is a photodiode (32).

12. System according to Claim 1, 10 or 11,
characterized in that said photodiode (32) is provided for being directly irradiated from both light sources (39, 40) for combining the optical signals.

13. System according to Claim 1, 10 or 11,
characterized by a bulk or fiber optical Y-type coupler (48) for combining the optical signals.

14. System according to Claim 1 or Claims 10 to 13,
characterized in that said electronic mixed signal is within the range of the low-frequency band.

15. System according to Claim 10 or Claims 10 to 14,
characterized by a signal processor (35) for processing, rectification and further analysis of the low-frequency useful signal.

16. System according to Claim 1 or Claims 10 to 15,
characterized by a tunable laser (38) for generating the reference radiation.

17. System according to Claim 1 or Claims 10 to 16,
characterized in that said tunable laser (38) is a diode laser or a fiber laser.

18. System according to Claim 1 or Claims 10 to 17,
characterized by a laser (38) that is commutable in increments and finely tunable within each segmental range for generating said reference radiation.

19. Method of monitoring the performance of DWDM multi-wavelength systems,
characterized in that a system according to Claims 1 to 18 is applied.

Abstract of the Disclosure

System and Method for Monitoring the Performance of Dense Wavelength Division Multiplexing Optical Communication Services

The invention relates to a system and a method for monitoring all the characteristic parameters of a DWDM communication system.

In accordance with the invention this is implemented with two variants. Firstly, this is achieved by means of a specific grating spectrometer 1 displaying a high resolution and a high-speed sampling of the measured values, secondly by the application of an opto-electronic cross correlator 2 as a purely electronic solution.

The grating spectrometer 1 is expediently a particular system in a mixed array according to Ebert and Fastie, wherein the light to be measured passes four times through the grating in a specific manner.

The opto-electronic cross correlator 2 can mix the working light with a reference light tunable in terms of its frequency to form an electrical low-frequency signal that is analyzed in a high-impedance operation.

List of the Figures

Fig. 1 shows the fundamental structure of a narrow-band optical band-pass filter consisting of a grating spectrometer and an analyzer unit

Fig. 2 illustrates the principle of the opto-electronic cross correlator

Fig. 3 shows the principle of the grating spectrometer with multiple passages

Fig. 4 illustrates an example of the structure and the optical path in the grating spectrometer with multiple passages

Fig. 5 shows the structure of the position sensor

Fig. 6 illustrates an example of an opto-electronic cross correlator

Fig. 7 illustrates the beam combination by means of fiber couplers

Fig. 8 is a view of a dual-channel opto-electronic cross correlator

Legend of the Figures

1	grating spectrometer
2	opto-electronic cross correlator
3	analyzer
4	reference oscillator, laser, reference laser
5	input signal, fiber optical waveguide, fiber input
6	low-pass filter
7	signal processor
8	position signal
9	reference unit
10	driving unit
11	photo detector, photodiode
12	grating drive
13	optical unit
14	display unit
15	mirror
16	mirror
17	mirror
18	mirror
19	mirror
20	mirror
21	mirror
22	mirror
23	dielectric preliminary filter, dielectric band-pass filter
24	grating
25	input, fiber input
26	output
27	collimator and camera mirror
28	position sensor
29	wave length calibrator
30	non-linear opto-electronic component
31	fiber input

32	detector, non-linear detector component, photodiode
33	low-pass filter
34	rectifier
35	signal processor
36	display unit
37	reference laser controller
38	tunable laser, reference laser
39	working beam
40	reference beam
41	secondary laser
42	optical system
43	grating
44	mirror
45	incremental scale
46	detector, line-shaped photodiode
47	polarizer
48	bulk or Y-type fiber coupler
49	polarizing beam splitter

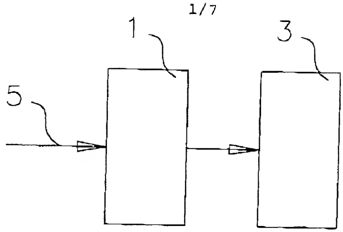

Fig. 1

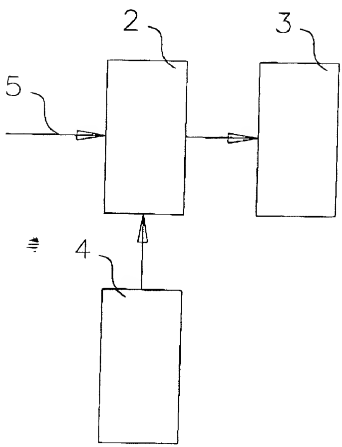

Fig. 2

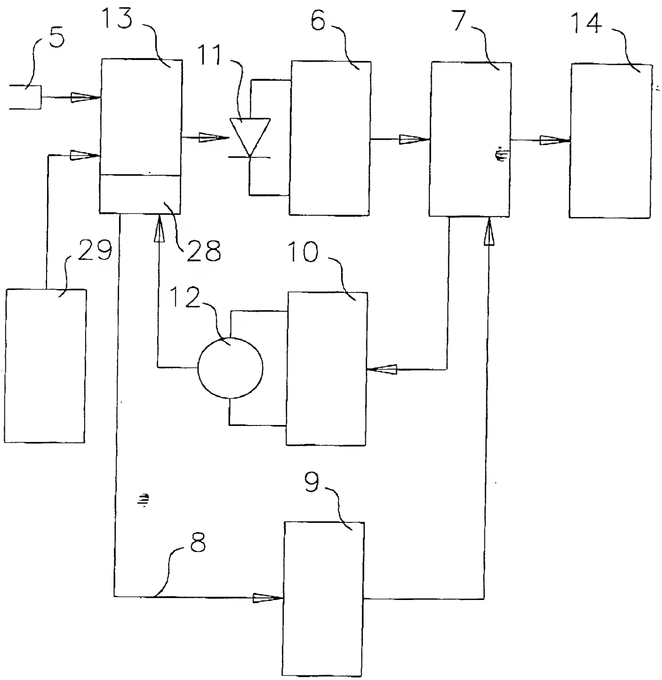

Fig. 3

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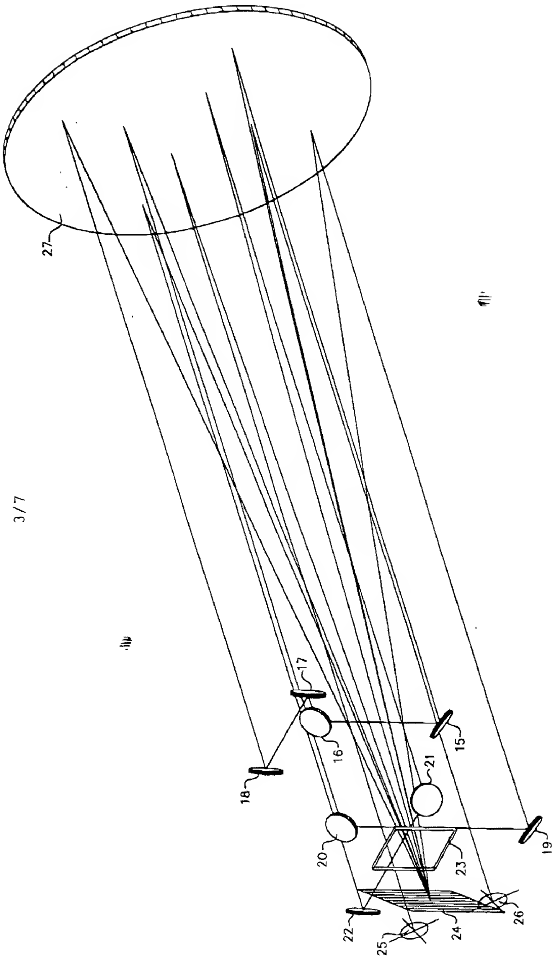

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Fig. 4

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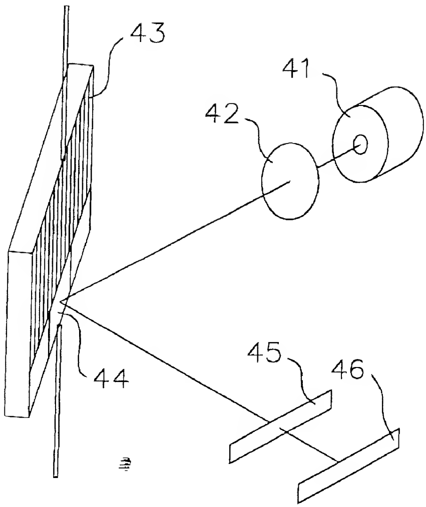

Fig. 5

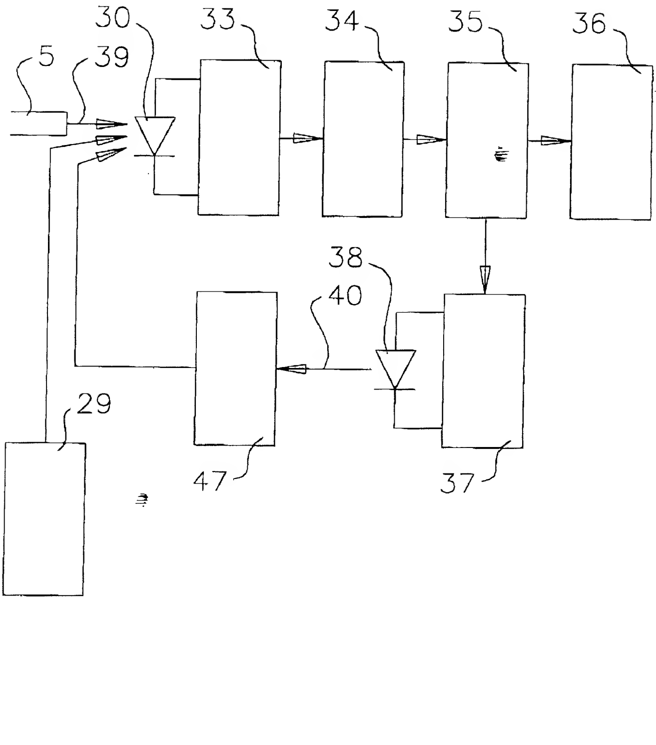

Fig. 6

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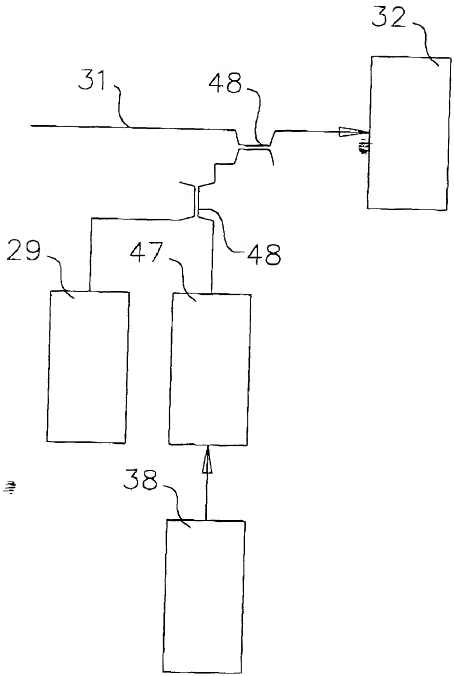

Fig. 7

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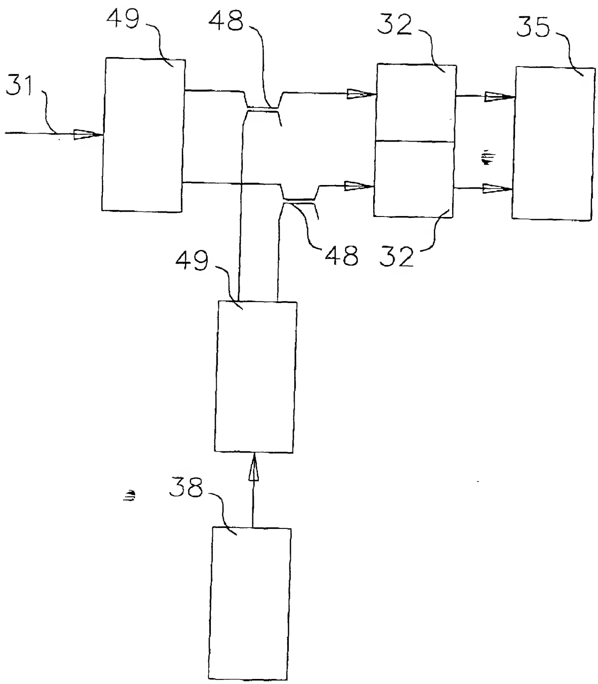

Fig. 8

Docket No.
3821.02

Declaration and Power of Attorney For Patent Application

English Language Declaration

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

System and Method for Monitoring the Performance of Dense Wavelength Division Multiplexing Optical Communicating Systems

the specification of which
(check one)

☐ is attached hereto.

☒ was filed on April 4, 2001 as United States Application No. or PCT International Application Number 09/806704
and was amended on ______________________
(if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d) or Section 365(b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)			Priority Not Claimed
(Number)	(Country)	(Day/Month/Year Filed)	☐
(Number)	(Country)	(Day/Month/Year Filed)	☐
(Number)	(Country)	(Day/Month/Year Filed)	☐

I hereby claim the benefit under 35 U.S.C. Section 119(e) of any United States provisional application(s) listed below:

(Application Serial No.)	(Filing Date)
(Application Serial No.)	(Filing Date)
(Application Serial No.)	(Filing Date)

I hereby claim the benefit under 35 U. S. C. Section 120 of any United States application(s), or Section 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. Section 112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, C. F. R., Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:

99/07340	PCT	pending
(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)
(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)
(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(list name and registration number)*

Charles S. Guenzer, Reg. No. 30,640 **Customer No.: 22337**

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1-00

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2-00

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